A Case Study of the Brooklyn Mine Reclamation Project[0]

Presented by

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ABSTRACT

In 1994, the Montana Department of Environmental Quality, Abandoned Mine Reclamation Bureau and the United States Department of Agriculture/Forest Service, Deerlodge National Forest entered into a pilot cooperative agreement to reclaim the Brooklyn Mine site. The Brooklyn Mine is an abandoned hardrock mine site located in the Flint Creek Mountains in Granite County, Montana. The primary objective of the Brooklyn Mine Reclamation Project was to protect human health and the environment from heavy metal contaminated mine wastes in accordance with guidelines set forth by the NCP in conjunction with newly developed procedures for AML reclamation. Site investigation and sampling activities led to the development of site reclamation engineering plans and specifications. The resulting reclamation construction project consisted of providing all labor, materials, earthwork, and incidentals to construct a waste repository; demolish and dispose of one metal building and miscellaneous debris; excavate, transport, and dispose of approximately 18,300 bank cubic yards of waste rock and mill tailings in the waste repository; recontour, topsoil, and revegetate the excavation areas; recontour, apply soil amendments, topsoil, and revegetate three additional waste rock dumps; and reconstruct approximately 525 feet of stream bank with fish habitat features.

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I. INTRODUCTION

The Brooklyn Mine site is located in the South Boulder Mining District of Granite County, Montana. The legal description of the Brooklyn Mine is Township 7 North, Range 12 West, S**2**, NE**3**, Section 5; latitude and longitude are North 46E 23' 25" and West 113E 07' 30", respectively. The mine site is located on the north side of the Boulder Creek drainage approximately five miles upstream from the town of Maxville. The site ranges in elevation from approximately 6,200 to over 6,500 feet above mean sea level. The terrain surrounding the mine is generally rugged, consisting of relatively steep slopes (15 to 20 degrees). Figure 1 provides an overview of the topography of the surrounding vicinity of the site (USGS, 1971).

Historical accounts indicate that one shaft and multiple adits were located at the Brooklyn Mine. Before reclamation, however, the shaft and all but one adit had collapsed or had been completely backfilled. A culvert and locking gate had been installed on the only open adit. Several cabins and collapsing wooden structures are also located on the property along with abundant wooden, sheet metal, piping, brick and concrete debris. The majority of the debris was located near the lower workings adjacent to Boulder Creek.

The Brooklyn Mine site waste sources consisted of four waste rock dumps and one tailings impoundment. Two of the six waste rock dumps were located very high up on a ridge (up to 500 feet higher in elevation than the streambed) in steep terrain. One waste rock dump and the tailings impoundment were located on a flat bench approximately 150 feet higher in elevation than the stream bed. The remaining waste rock dump, and by far the largest, is located directly adjacent to Boulder Creek and was actively being eroded into the creek. The total volume of waste rock that was present at the site totaled 38,000 cubic yards. The volume of tailings that was present on-site totaled 4,800 cubic yards. These waste materials contained elevated levels of: arsenic, barium, cadmium, copper, mercury, lead, antimony and zinc.

The purpose of this reclamation project was to limit human and environmental exposure to the contaminants of concern and reduce the mobility of these contaminants to mitigate impacts to local surface and groundwater resources.

II. PROJECT COOPERATION

The Brooklyn Mine site is located on land administered by the United States Department of Agriculture/Forest Service (USFS), Deerlodge National Forest. Discussions between The Montana Department of Environmental Quality (MDEQ/AMRB) and the USFS regarding reclamation of the Brooklyn site led to a cooperative agreement between the agencies. This agreement provided for a jointly funded and administered reclamation project to mitigate environmental impacts resulting from the Brooklyn Mine site.

III. RECLAMATION PROCEDURE

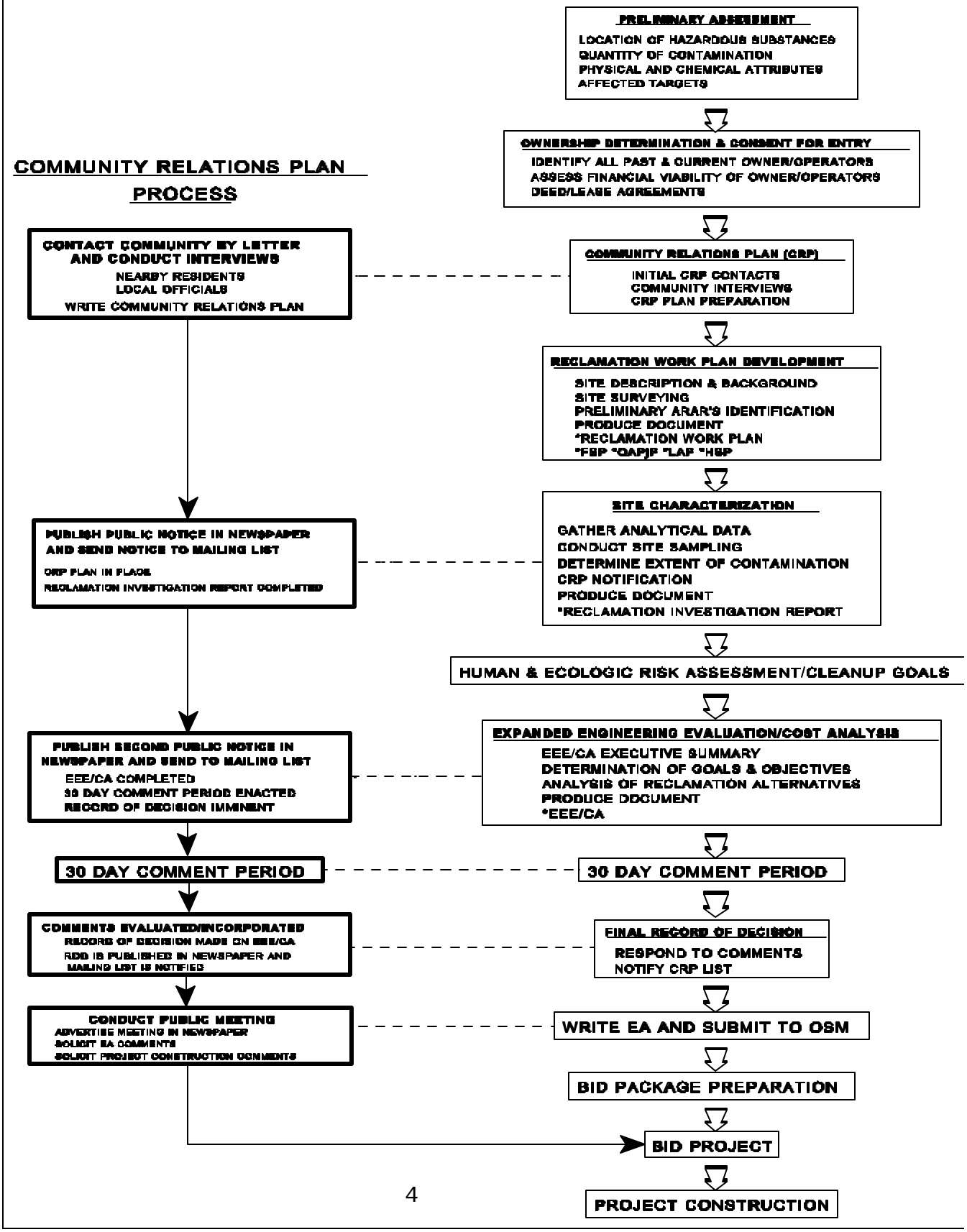
The Brooklyn Mine was an abandoned hardrock mine site listed on the Montana Department of Environmental Quality, Abandoned Mine Reclamation Bureau Priority Sites List. The Brooklyn Mine site was inventoried, ranked and identified as a hazardous hardrock mine in 1993. MDEQ/AMRB selected the site for reclamation and planning activities began in 1994. Figure 3 has been prepared to guide the reviewer through the clean-up process for the Brooklyn site. This process has been designed to comply with the requirements of the National Contingency Plan (NCP); the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); and the Montana Comprehensive Environmental Clean-up and Responsibility Act (CECRA), while stream-lining certain aspects of the process to better meet the regulatory and functional needs of cleaning up relatively small abandoned mine sites that are generally situated in remote locations.

The reclamation procedure (shown in Figure 3) has been developed by the MDEQ-AMRB to guide **non-NPL listed CERCLA site removal actions.** This procedure is a hybrid version of the traditional NCP CERCLA removal process. It is more stringent than a CERCLA removal action, yet designed to function more efficiently than a CERCLA site remediation action. The Brooklyn Mine site removal action is supported by the following documents:

A). Preliminary Site Inventory Report
B). Owner/Operator History Report
C). Community Relations Plan (CRP)
D). Reclamation Work Plan
E). Reclamation Investigation Report (RI)
    1). Field Sampling Plan (FSP)
    2). Quality Assurance Project Plan (QAPjP)
    3). Laboratory Analytical Protocol (LAP)
    4). Health and Safety Plan (HSP)
F). Expanded Engineering Evaluation/Cost Analysis (EEE/CA)
G). Environmental Assessment (EA)
H). Construction Bid Package/Engineering Design

Following is a brief description of the required NCP removal action supporting documents:

ABANDONED INACTIVE MINE CLEANUP PROCEDURE



Preliminary Site Inventory Report

This report contains field reconnaissance data collected at hazardous hardrock mining/milling sites in Montana. The collected data is used to rank sites based on the magnitude of negative effects to human health, safety and the environment.

Owner/Operator History Report

This report identifies current and past owners and mine and mill operators. The report contains title abstracts, summaries of historical mining and milling operations, and corporate, financial, and other information about companies who were actively involved in mining and milling in the site area.

Community Relations Plan (CRP)

The Community Relations Plan outlines the community involvement activities conducted during the investigation and cleanup activities at the Brooklyn Mine site. The purpose of the CRP is to: involve the local community in the project process, to identify concerns of people affected by the site, and to develop methods to address those concerns.

Work Plan

The Reclamation Work Plan was prepared to be a functional guide for conducting the full-scale reclamation at the Brooklyn site. Existing data available for the site is evaluated, and preliminary risk analysis and the equivalent of a CERCLA Phase I and II Feasibility Study (FS) is performed and is presented in the Work Plan.

Reclamation Investigation (RI)

The objectives of the Reclamation Investigation Report are to: 1) describe in detail, the field activities conducted at the site; 2) present the data obtained for the site; 3) perform a human health and ecologic baseline risk assessment; and 4) interpret the results derived from the field activities as they pertain to the reclamation alternatives proposed for the site.

Field Sampling Plan (FSP)

The Field Sampling Plan presents the sampling approach for the Brooklyn Mine site Remedial Investigation. This FSP also contains the Standard Operating Procedures (SOPs) for conducting the field sampling activities. This FSP is a supporting document to be used in conjunction with the Reclamation Work Plan.

Quality Assurance Project Plan (QAPjP)

The QAPjP describes quality assurance for the remedial investigation of the Brooklyn Mine site. The QAPjP is a supporting document for the Field Sampling Plan.

Laboratory Analytical Protocol (LAP)

The Laboratory Analytical Protocol describes laboratory requirements for the remedial investigation. Analysis of water and solids (streambed sediments, waste rock features, tailings features, or soil) is expected. All analytical work is to follow the requirements listed in this document for the duration of the project.

Health and Safety Plan (HSP)

The purpose of this document is to set forth the minimum acceptable requirements and procedures for a Health and Safety Plan for contractors and all subcontractors. All work practices and procedures are designed to minimize exposure to hazardous materials and to eliminate any possibility of physical injury to contractor employees, MDEQ/AMRB personnel, subcontractors, and the nearest communities.

Expanded Engineering Evaluation/Cost Analysis (EEE/CA)

The primary purpose of this report was to present the detailed analysis of reclamation alternatives in accordance with the NCP. In addition, the site background, waste characteristics, Applicable or Relevant and Appropriate Requirements (ARARs), risk assessment, and the development and screening of alternatives are presented herein. The purpose for providing this supplemental information to the detailed analysis of alternatives is to give the reviewers and risk managers a comprehensive "stand-alone" decision making tool.

Environmental Assessment (EA)

The purpose of the Environmental Assessment is to satisfy project NEPA/MEPA requirements and serve as an Office of Surface Mining Grant application for Abandoned Mine Reclamation Project funding.

Construction Bid Package/Engineering Design

The construction bid package contains the reclamation engineering design and project plans and specifications as well as all contractor proposal information.

IV. SITE INVESTIGATION

Site investigation field activities conducted at the Brooklyn Mine focussed on collecting sufficient data to perform a human health and ecological risk assessment, as well as a detailed analysis of reclamation alternatives. Data collected to support the risk assessment included the following:

- Characterization of heavy metal concentrations, both vertically and laterally in each waste source, and isolation of the 0 to 6 inch depth zone for direct contact and wind erosion (air release) exposure evaluation.

- Establishment of background soil concentrations with multiple (five) background soil samples;

- Evaluation of the physical and chemical properties of the source materials that effect contaminant migration, including: pH, buffering capacity, organic carbon content, and particle size distribution;

- Evaluation of groundwater;

- Characterization of impacts to surface water (Boulder Creek) with regularly spaced surface water and corresponding stream sediment samples located upstream, adjacent to, and downstream from the site.

Data collected to support the detailed analysis of reclamation alternatives (Feasibility Study) included the following:

- Accurate areas and volumes of the contaminant sources (waste rock and mill tailings);

- Contaminant concentration variations and leaching characteristics of the wastes [Toxicity Characteristic Leaching Procedure (TCLP), porosity, hydraulic conductivity, pH];

- Revegetation parameters for waste rock dumps and cover soil sources including: liming requirements; soil texture and particle size; fertilizer recommendation; organic matter content; and identification of suitable native plant species; and

- Soil characteristics of potential repository site locations.

All site waste sources were sampled by collecting solid-matrix samples for in-the-field analyses of total metals utilizing a field portable X-Ray Fluorescence (XRF) spectrometer. Approximately 10% of all samples taken were split, with half of the sample sent to a laboratory for CLP metals analyses. This sampling methodology allows: greater field sampling flexibility, a greater number

of sample analysis, reduced cost and redundant laboratory analysis to provide XRF accuracy verification.

Following data collection and analysis, a baseline human health risk assessment was completed. The risk assessment examined the effects of taking no action at the site. The assessment involved four steps: hazard identification; exposure assessment; toxicity assessment; and risk characterization. These four tasks were accomplished by evaluating available data and selecting contaminants of concern, identifying potentially exposed populations and exposure pathways, estimating exposure point concentrations and intakes, assessing toxicity of the contaminants of concern, and characterizing overall risk by integrating the results of the toxicity and exposure assessments.

Based on the characterization data, the baseline human health risk assessment calculation for the Brooklyn Mine identified soil ingestion of arsenic and lead, and water ingestion of lead as presenting the highest human health risk.

An ecological risk assessment was also completed. This assessment involved: 1) identification of contaminants, ecologic receptors, and ecologic effects of concern; 2) exposure assessment; 3) ecologic effects assessment; and 4) risk characterization. These four tasks were accomplished by evaluating available data and selecting contaminants, species and exposure routes of concern, estimating exposure point concentrations and intakes, assessing ecologic toxicity of the contaminants of concern, and characterizing overall risk by integrating the results of the toxicity and exposure assessments.

The ecological risk assessment calculation for the Brooklyn Mine identified: aquatic life effects from lead in water, and arsenic, lead and zinc in sediments; elk ingestion from lead salts; and plant phytotoxicity from arsenic, cadmium, copper, lead and zinc as presenting the highest ecological risks.

The risk assessment helped to identify the following site cleanup goals: Carcinogenic goal - reduce arsenic concentration to background (. 20 mg/kg); and Noncarcinogenic goal - reduce lead concentration to 1,500 mg/kg.

V. RECLAMATION ALTERNATIVES

The following reclamation alternatives were developed and evaluated for the Brooklyn Mine site:

ALTERNATIVE 1	NO ACTION
ALTERNATIVE 2	INSTITUTIONAL CONTROLS
ALTERNATIVE 3	IN-PLACE CONTAINMENT
ALTERNATIVE 4a	ON-SITE DISPOSAL IN A CONSTRUCTED RCRA SUBTITLE C REPOSITORY
ALTERNATIVE 4b	ON-SITE DISPOSAL IN A CONSTRUCTED MODIFIED RCRA REPOSITORY
ALTERNATIVE 4c	ON-SITE DISPOSAL/CONTAINMENT USING A MODIFIED RCRA CAP
ALTERNATIVE 5	OFF-SITE DISPOSAL IN A RCRA-PERMITTED HAZARDOUS WASTE DISPOSAL FACILITY.
ALTERNATIVE 6	OFF-SITE TREATMENT OR REPROCESSING

The alternatives were assessed based on the following 7 NCP criteria:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

Based on detailed analysis and comparative analysis of alternatives, Alternative 4b: Disposal in a Constructed Modified (Single Lined) RCRA Repository was selected as the preferred alternative by the MDEQ/AMRB and the USFS. This alternative involved construction of a single-lined, mine waste repository with a multi-layered cap. This alternative was deemed the most appropriate and cost-effective means to reduce risk to human health and the environment to an acceptable level.

VI. PROJECT CONSTRUCTION

A stream diversion structure was necessary to isolate Boulder Creek from the waste rock excavation activities. Due to the tight time frame associated with this project, the stream diversion structure was procured and installed by Pioneer with the assistance of the Montana Conservation Corps., before the construction contractor mobilized to the site. The diversion structure was constructed from half-round 36-inch diameter corrugated metal pipe. The pipe was raised slightly above the creek bed on jack-leg supports at ten foot centers to maintain a constant seven percent grade. A small temporary diversion was constructed at the inlet to divert the majority of the flow of Boulder Creek into the pipe.

The construction contract work involved removing those waste sources at the Brooklyn Mine which were the principal sources of concern (the tailings pond and waste rock dump #5) and disposing of these wastes in a constructed repository. The repository was constructed on the bench area located directly south of waste rock dump #3. The repository bottom consists of a single geosynthetic clay (GCL) bottom liner with an integral drainage layer and a low maintenance leachate collection and removal system. A secondary layer of B-Grade (off-specification) GCL was installed to protect the primary liner from potential chemical reaction. The total surface area of the repository required to contain the specified wastes is approximately 1.5 acres. Approximately 3.0 acres of timber was removed to accommodate repository construction and removal of tailings dispersed throughout sparsely timbered areas. After the specified wastes were loaded and compacted in the repository, a multi-layered, lined cap was constructed overlying the wastes, and the cap was fertilized, seeded, and mulched. The excavated areas (tailings and waste rock dump #5 locations) were backfilled to contours matching the surrounding topography, fertilized, seeded, and mulched. The stream channel adjacent to waste rock dump #5 was reconstructed in a step-pool configuration similar to the undisturbed stream channel located upstream of the project. Excess soil originating from the repository excavation was amended with compost and used as cover soil in the excavated areas. In addition, a subsurface limestone french drain was constructed below the adit located at waste rock dump #5 to treat a minor intermittent adit discharge.

The other large waste rock dumps located at the site (waste rock dumps #1, 2, and 3) were graded out to match the surrounding topography. Lime was incorporated into the upper 12-inches of the dump material, as needed. The dumps were covered with soil (previously amended with compost), fertilized, seeded, and mulched in place. Excess soil from the repository excavation was also used to cover the waste rock dumps. Slopes flatter than 2.5:1 were mulched by crimping straw and drill seeded. Slopes steeper than 2.5:1 were hydroseeded with a mixture of wood fiber mulch, seed, fertilizer, and tackifer. Additionally, biodegradable erosion control mat (straw/coconut fiber woven mat) was installed on slopes steeper than 2.5:1 following the hydroseeding procedures.

Ditches were constructed to divert run-on away from each of the reclaimed areas and the

repository. Temporary fences were constructed to surround each of the reclaimed source areas as well as the repository cap to allow for the establishment of vegetation without interference from livestock or wildlife. Several of the temporary roads constructed at the site were obliterated and reclaimed; however, some of the roads remain intact to allow access for monitoring the progress of the reclaimed areas (and maintenance when necessary) for a period of one to several years.

VII. SUMMARY

The Brooklyn Mine Reclamation Project was completed on schedule and within the engineer's cost estimate. All project objectives were accomplished. The project took 67 consecutive calendar days to complete (from August 1, to October 6, 1995).

The construction cost for this project was $767,895.00. The total engineering cost for this project was $236,380.00. The Work Plan, Field Sampling Plan, and other supporting documents for the Brooklyn site cost $52,131.00. The reclamation investigation and risk assessment cost $57,217.00. Preparation of the Expanded Engineering Evaluation/Cost Analysis for the Brooklyn site cost $34,600.00. Engineering design and bid specification preparation cost $42,372.00. Construction management including engineering administration and inspection cost $50,060.00. Construction of the Boulder Creek stream diversion structure cost $25,441.00. The total project cost was $1,029,717.00.

Costs associated with work plan preparation and site characterization are higher than typically encountered due to the inclusion of an additional site analysis during that phase of the project. The Brooklyn Mine was a successful pilot project which tested newly developed procedures for: 1) establishing working cooperative agreements, and 2) conducting abandoned hardrock mine/mill site reclamation meeting the requirements of the NCP.

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